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Cladding Attachment - Laboratory Research and Design

- University of Waterloo – Env. Eng’g
- Met Dr. Straube
 - Masters in Building Science
 - Drainage in Small Cavities in Wall Systems
 - Instrumentation/Research
- Hired by BSC
- Laboratory research, test huts, site investigations, air leakage testing,



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Acknowledgements

- Roxul
- United States Department of Energy Building America Program
- BSC Colleagues



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Presentation Outline

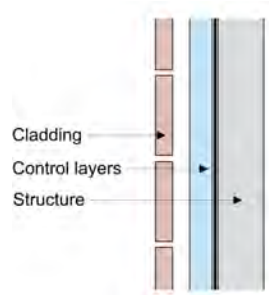
- Review Perfect Wall
- Cladding Attachment
- Laboratory Research/Design Criteria
 - Short term deflection
 - Long term deflection
 - Exterior testing
- Masonry Cladding Attachment



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The “Perfect” Wall

- Increase overall thermal performance
 - Combination of exterior and cavity insulation
- Minimize thermal bridges
- Minimize potential for air leakage condensation
- Improve air tightness?
- Improve rainwater management?



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1980s ON – a “weird” builder



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1990s ON – a “good” builder



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1995 – 2pcf



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2000s ON – a “typical” builder



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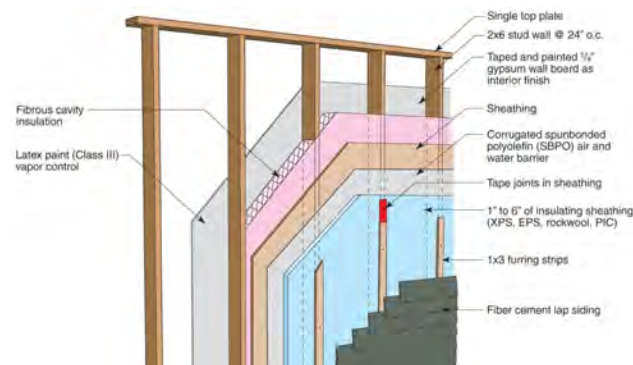
Cladding Attachment

- For insulation 1.5” or less – direct attachment of cladding though insulation back to the structure is often practical
- For insulation greater than 1.5” – a secondary cladding support system is often needed.
 - Not practical to attach cladding through thick insulation layers
 - Building Codes have moved to continuous insulation in many cases over North America
- There are many options to structurally support cladding with thick layers of exterior insulation. There are issues with many of them.
 - Thermal bridging (eg. Z-furring)
 - Costly
 - Proprietary Systems
 - Custom solutions
 - Minimum number of holes in control layers of Perfect Wall



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Cladding Attachment



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Furring Strips (strapping)

- Furring strips can be attached through the insulation to the structure of the building which provides a location to attach the strapping normally.
- Not only does this provide cladding attachment but also has the benefit of producing a $\frac{3}{4}$ ” cavity that provides a capillary break, drainage, and ventilation drying
- Our experience in low rise residential is that these furring strips do not need to be pressure treated.



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Cladding Attachment ~17 years ago



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Joseph LaBourek 14



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Joseph LaBourek 15

2000s MA – a “High-R” assembly



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2000s – “High-R” retrofit



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Juneau, AK (2005) (BSI-031 Building in Extreme Cold)



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Concerns of Cladding Movement

- All of the insulation materials aren't structural materials/products. The general concern with all of them is that they are all relatively soft.
- We started getting questions from product manufacturers and designers about the risk of cladding creep. What will happen?
- We still get questions about this to this day.
 - “As you may recall we will have 1” of insulation board beneath the stucco. (CA building code will require 2” in 2014). When this first came up a couple of years ago every stucco contractor expressed concern about the stucco falling off the studs due to weight and the length of the nails, this defines the so called “nailing problem”.”



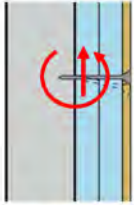
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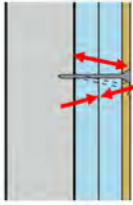
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Discrete Load Components


- Discrete Load Components




Shear and rotational resistance provided by fastener to wood connections



Rotational resistance provided by tension in fastener and compression of the insulation



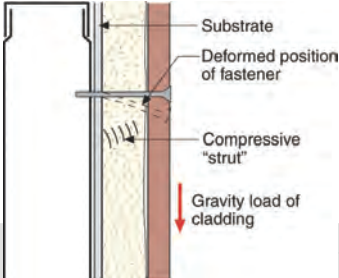
Vertical movement resistance provided by friction between layers



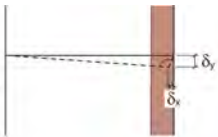
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Cladding attachments

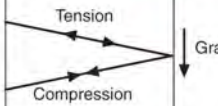
- Insulating on exterior is not a structural challenge ... unless you use the wrong model
- Bending does matter, but only at high deflections




Geometry



Force







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Previous Research

- Started thinking about this in 2008
- At this time there was no information available on the movement of cladding or strapping fastened through exterior insulation





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Foam sheathing field testing






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Direct Attachment Through Insulation

- 2010
- “Does the insulation provide any additional capacity for the system?”
- BSC staff test



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Direct Attachment Through Insulation

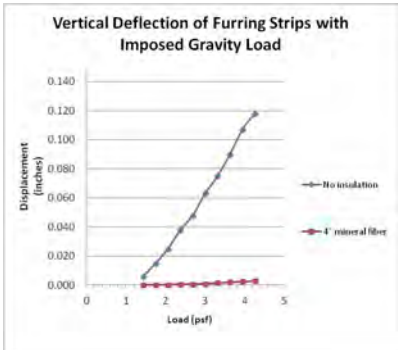
- System loaded with 4” of rigid mineral fiber insulation between furring and wall



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Direct Attachment Through Insulation



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BSC Laboratory Research


- Develop a method to determine the predicted deflection under various cladding weights on wood framed wall assemblies.
- What variables to test?
 - Insulation type, thickness, fastener spacing, type, furring spacing etc.
- Reasonable worst case scenario standard construction. (maximum safety factor)
- Off the shelf components
 - Fasteners, strapping (1x3)


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Short Term Deflection Testing

- Wood frame, OSB, plastic housewrap, insulation, 1x3 strapping





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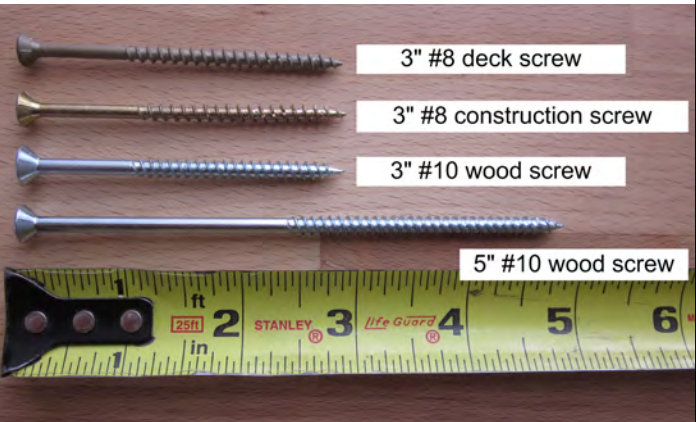
Applying weight to strapping







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Strapping Attachment







3" #8 deck screw



3" #8 construction screw



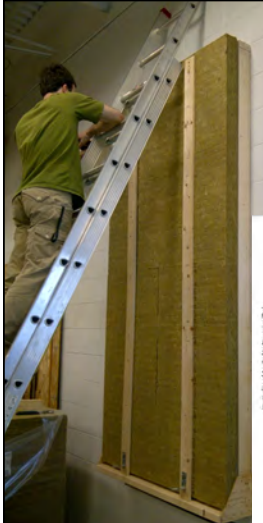
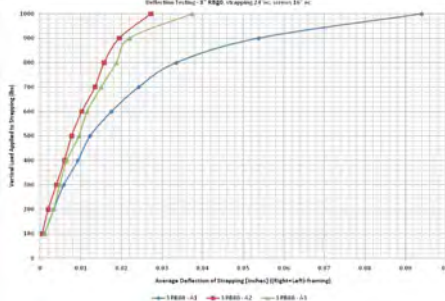
3" #10 wood screw



5" #10 wood screw

Rockwool

1x3 furring @ 24" o.c.
 #10 screws @ 16" o.c. vertically
 Result: 20 psf (640lb adhered stone)
 cladding weight with < 2/100" deflection
 report is on Roxul website

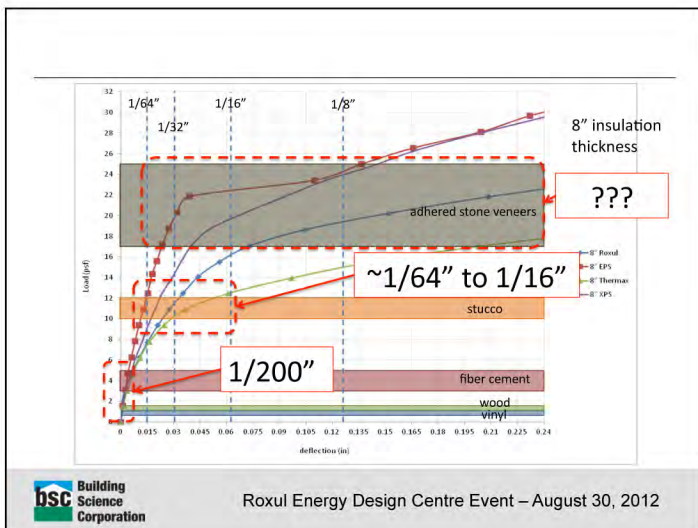
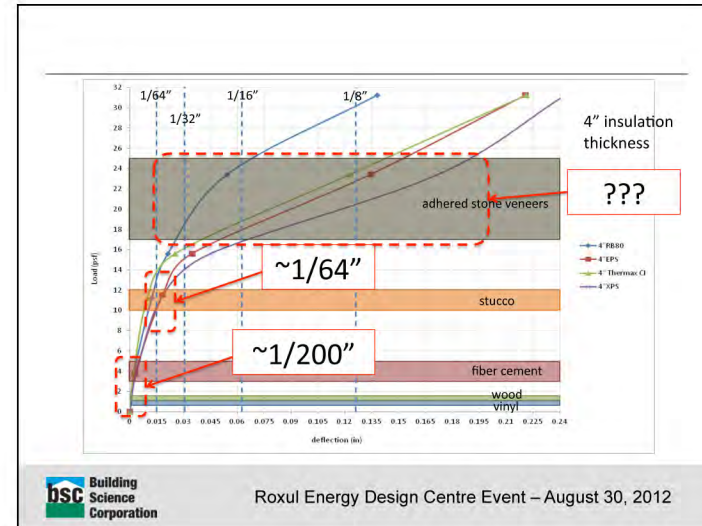



Direct Attachment Through Insulation

- Typical cladding weights (psf)

	low	high
Vinyl	0.6	1.0
wood	1.0	1.5
fiber cement	3.0	5.0
stucco	10.0	12.0
adhered stone veneers	17.0	25.0

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What constitutes failure?

- Acceptable deflection not ultimate capacity governs
- What is acceptable deflection?
 - Movement a cladding system can accommodate without physical damage or exceeding aesthetic tolerances
- Proposed limits
 - Lap sidings and panel cladding ~ 1/16"
 - Brittle claddings ~1/64" (after initial deflection)

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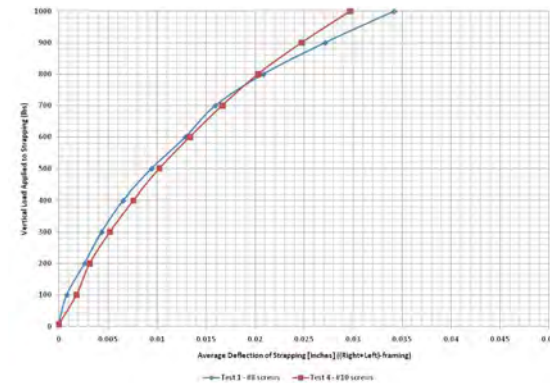
Testing Results – Summary

- Lightweight claddings (vinyl, wood, fiber cement) have very little movement (~1/200")
- For lightweight claddings deflection does not even approach proposed deflection limit (1/16")
- Testing results in line with long history of performance of buildings constructed with this assembly
 - So what insulation do you use?
- Heavier brittle claddings (stucco, adhered stone veneers) initial deflection is not as important as **long term deflection**



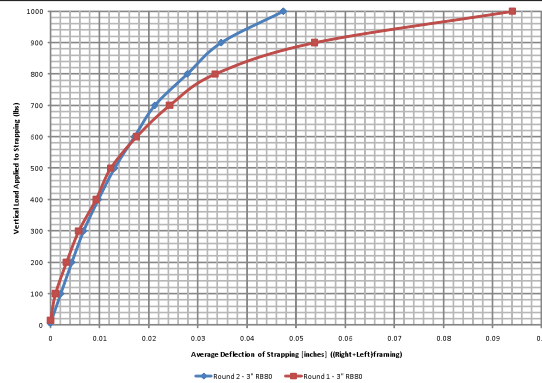
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Screw Comparison



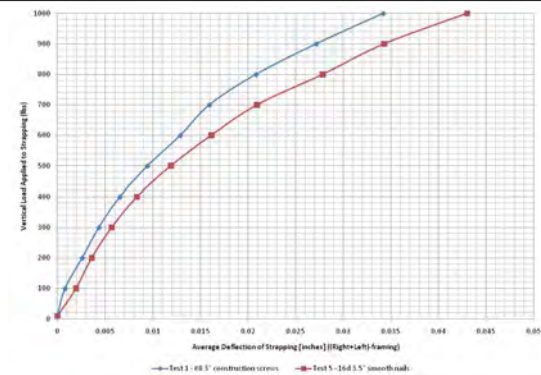
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Repeatability



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Fastener Type



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Long-term Gravity Load Response

- Long term testing
- Test panels
 - 16"x96"
 - 1x3 furring
 - 16" vertical spacing of fasteners
- Load
 - 20 psf
 - 30 lb/fastener



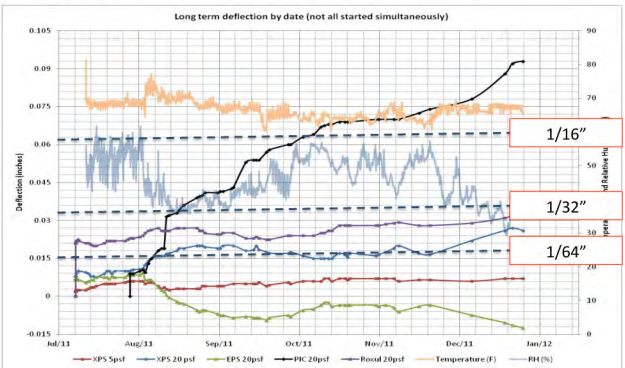
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Long-term Gravity Load Response



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Long-term Gravity Load Response



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Additional Questions

- Creep is still not well understood or quantified
- Affected by multiple factors
 - Expansion and contraction of wood
 - Expansion and contraction of insulation
 - Relaxation of wood fibers
 - Plastic deformation of insulation
- Many of these are affected by temperature and relative humidity
- More research is needed to examine the performance of these systems in exposed environments

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Climate Exposure

- Full Scale Wall Assemblies
- Loaded to three representative cladding weights
 - Fiber cement
 - Stucco
 - Cultured stone
- Deflection measured over the course of the year



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Climate Exposure



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Climate Exposure



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Climate Exposure



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Additional Questions

- The exact mechanisms of the load deflection resistance are not well quantified
- Discrete load components are theorized but have not been measured
- Important to understand factors that affect the development of system capacity to examine means to design the attachment systems



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Gravity Load Response Testing (2012)

▪ Discrete Load Components



Shear and rotational resistance provided by fastener to wood connections



Rotational resistance provided by tension in fastener and compression of the insulation



Vertical movement resistance provided by friction between layers



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Discrete Load Component Testing

- Series of tests to measure material properties
 - Coefficients of friction
 - Compression modulus of insulation
- Small scale test to try to isolate the discrete functions
 - Screw bending/wood bearing
 - Strut and tie model
 - Friction between layers
 - Due to pre-compression (clamping) forces
 - Due to rotational forces



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Discrete Load Component Testing

- Pre-compression (clamping) forces
 - Forces imposed on the system by tightening of the screw fasteners that hold the wood furring in place
 - Tested using common #10 Wood Screws



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Discrete Load Component Testing

- Pre-compression (clamping) forces
 - Failure mechanism – head pull through of fastener through the furring
 - Preliminary results indicate pretty consistent force magnitudes
 - ~ 150 lbs per fastener with screw head flush with furring surface
 - ~ 180 lbs per fastener with screw over driven
 - Additional testing to be completed to examine relaxation in load over time



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Discrete Load Component Testing

- Small Scale Discrete System Tests
 - Custom built test apparatus
 - Intent to evaluate individual force resistance components
 - Screw bending/wood bearing
 - Strut and tie model
 - Friction between layers



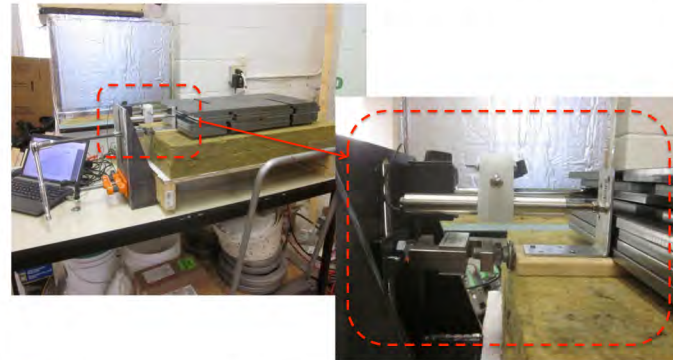
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Discrete Load Component Testing



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Discrete Load Component Testing



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Further Testing

- Previous testing entirely focused on wood framed walls, typically residential construction
- There is a plan to test some steel stud walls, with DensGlass, Roxul CIS insulation, and various cladding attachment strategies.
 - The same overall goals will apply, cost effective, reduce thermal bridging, common materials

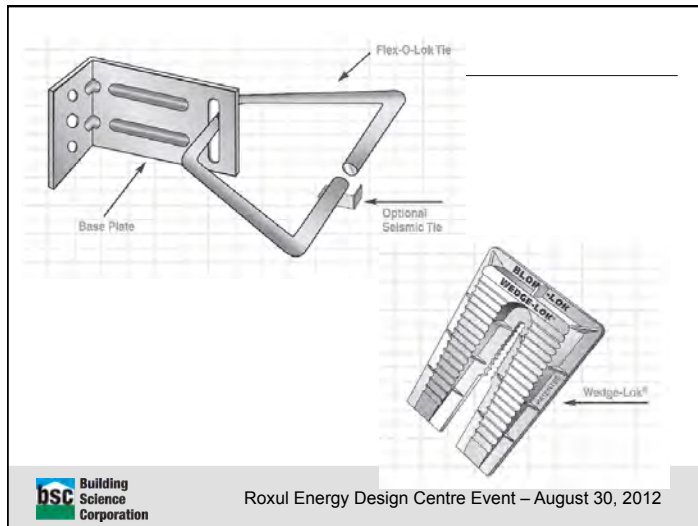


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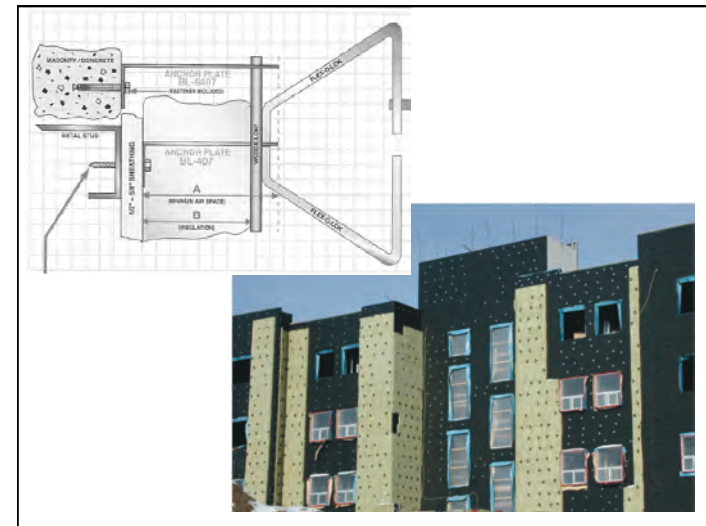
Masonry Cladding Attachment

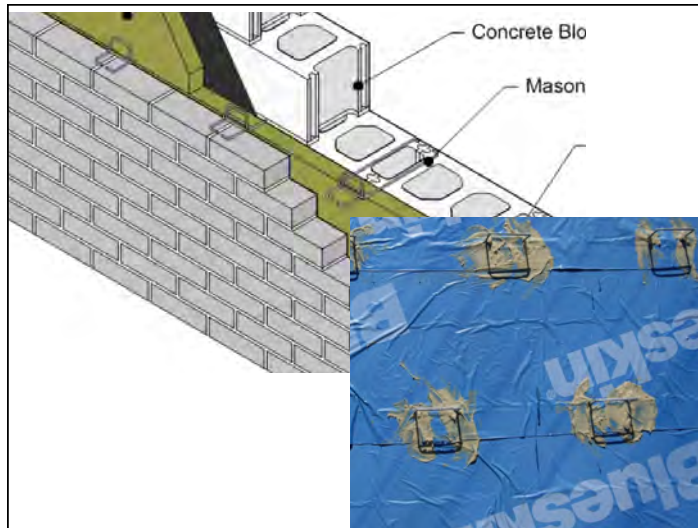


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Further Information

- Deflection report for Roxul
 - <http://www.roxul.com/residential/products/roxul+comfortboard+is>
 - Listed under “downloads”
- BSC Website
 - www.buildingscience.com
 - Research Report 1204 – P.Baker



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